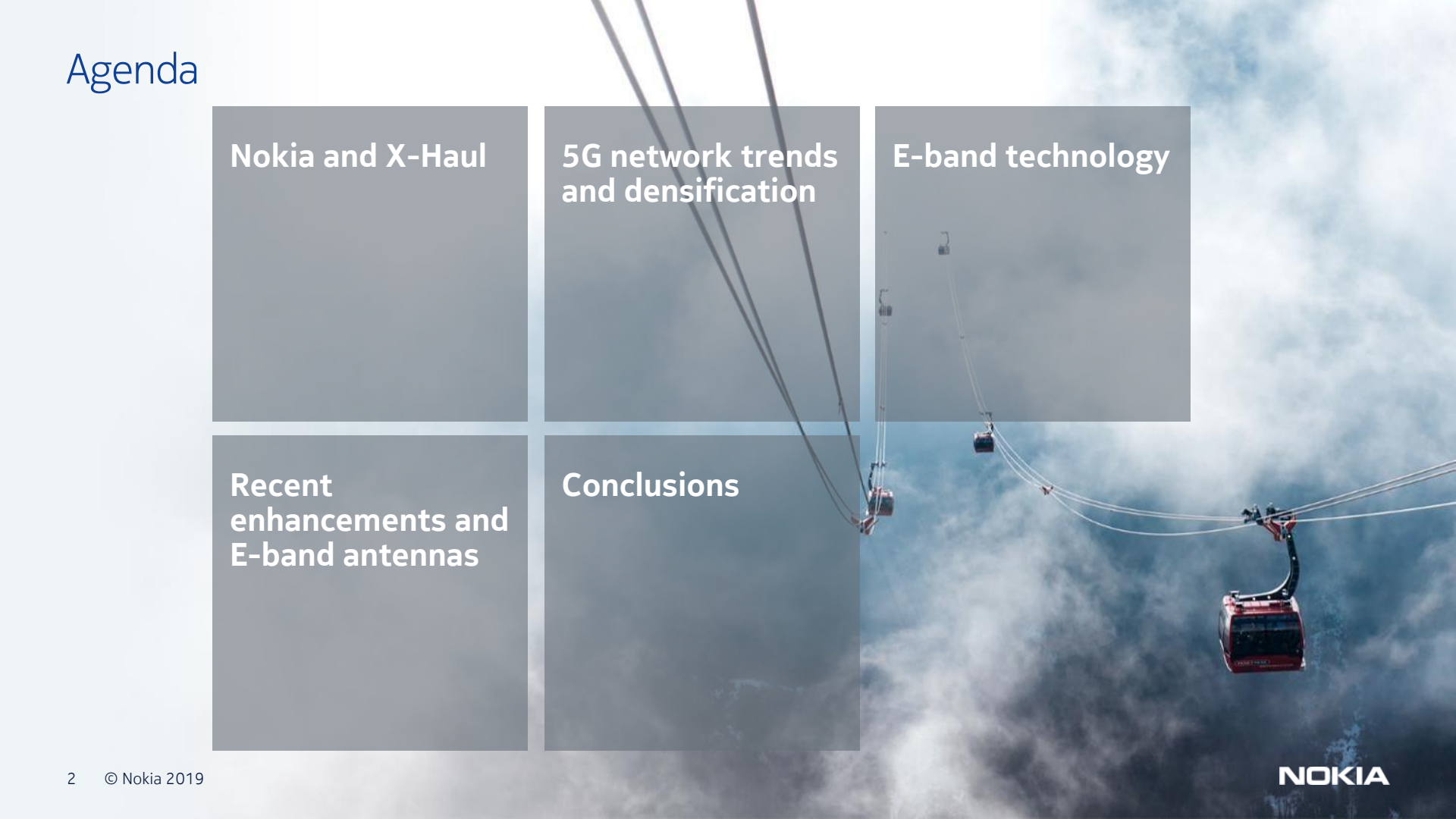
70-80 GHz for 5G backhaul

Densification scenario

June 14, 2019

Agenda

- Nokia and X-Haul
- 5G network trends and densification
- E-band technology
- Recent enhancements and E-band antennas
- Conclusions



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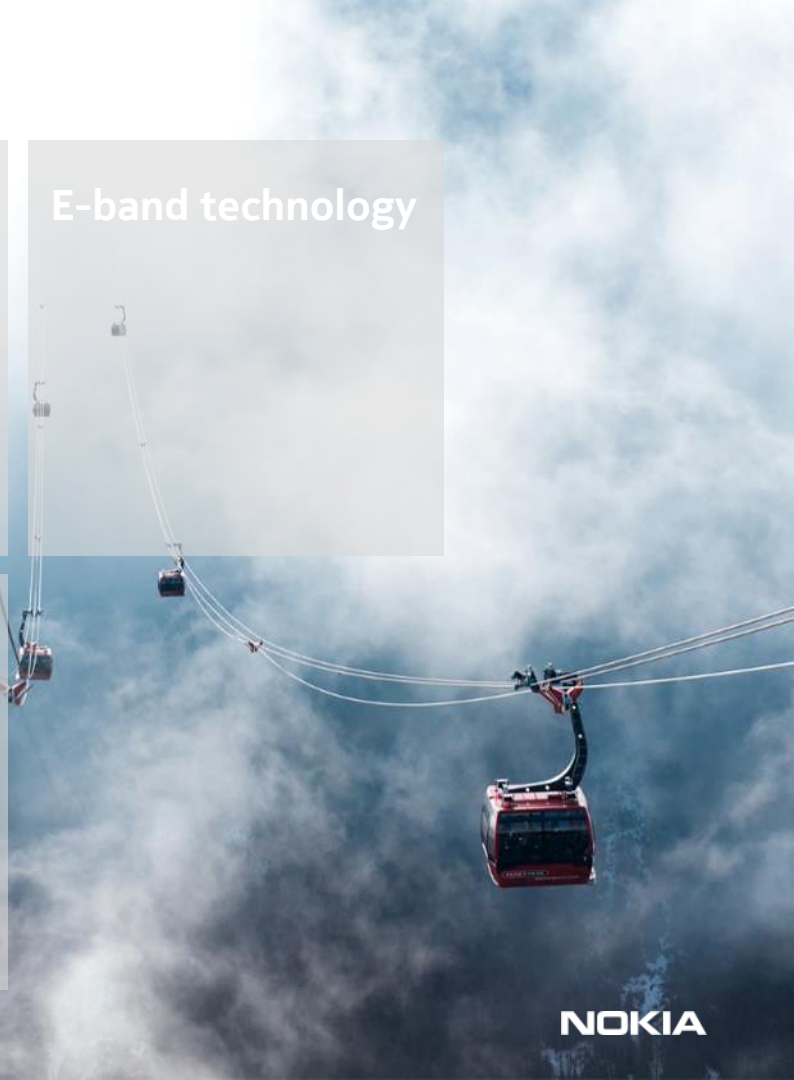

Mobile Network X-Haul Business Unit

Nokia Microwave Worldwide

Nokia Microwave presence in US

- Nokia Microwave #1 in US
  - Mobile backhaul
  - TEPS/Verticals
- Over 60 years in the microwave business
- Main supplier to ATT, VzW and First Responder networks
- Nokia Microwave #1 in Vertical market

5G Engagement

First 5G site mid-hauled in Q418

Many 5G trials with MW transport:

US Canada Italy Germany Saudi …

UBT Twin

UBT S

UBT m 80

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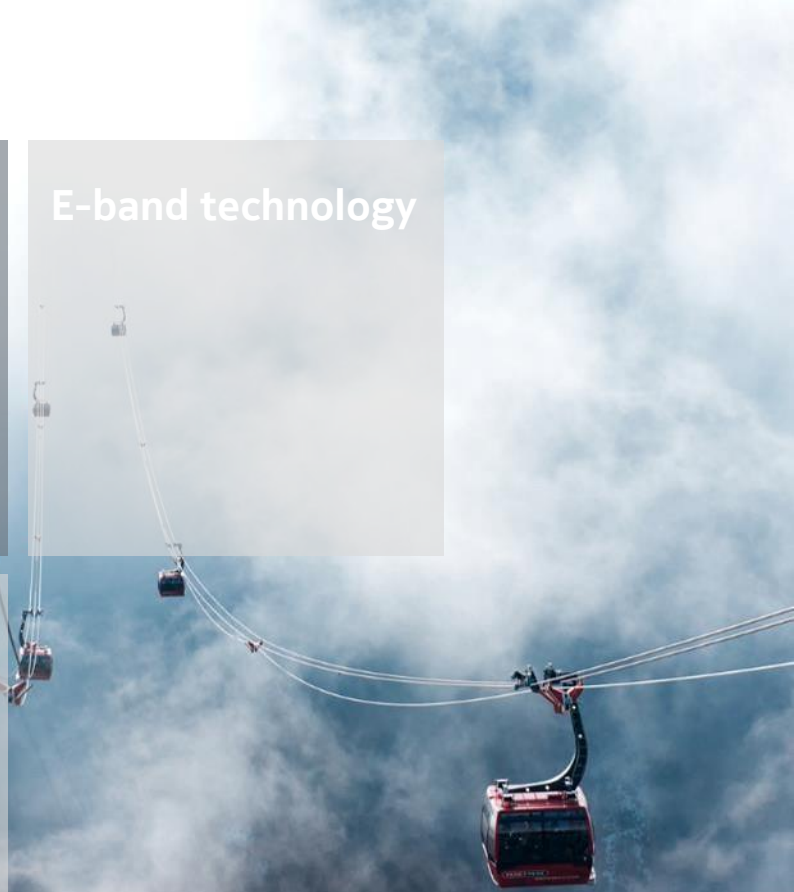
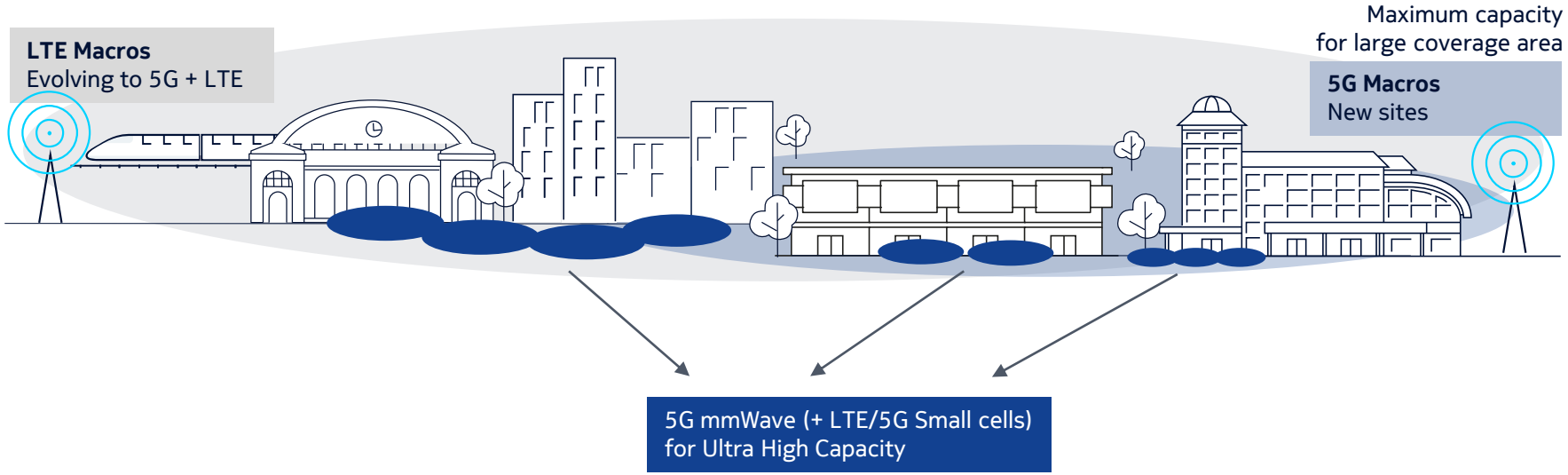


5G Densification

Small Cells and 5G mmWave complement high performance 5G macro solutions

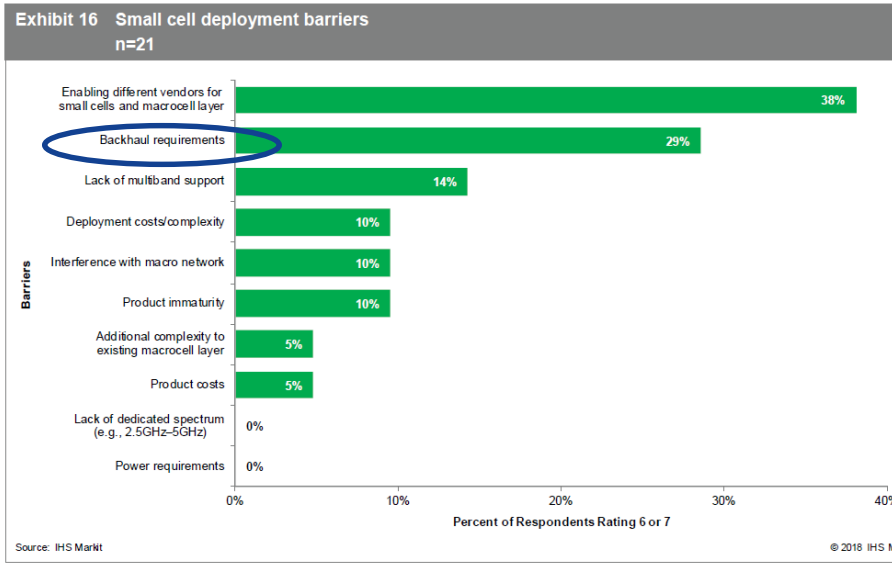


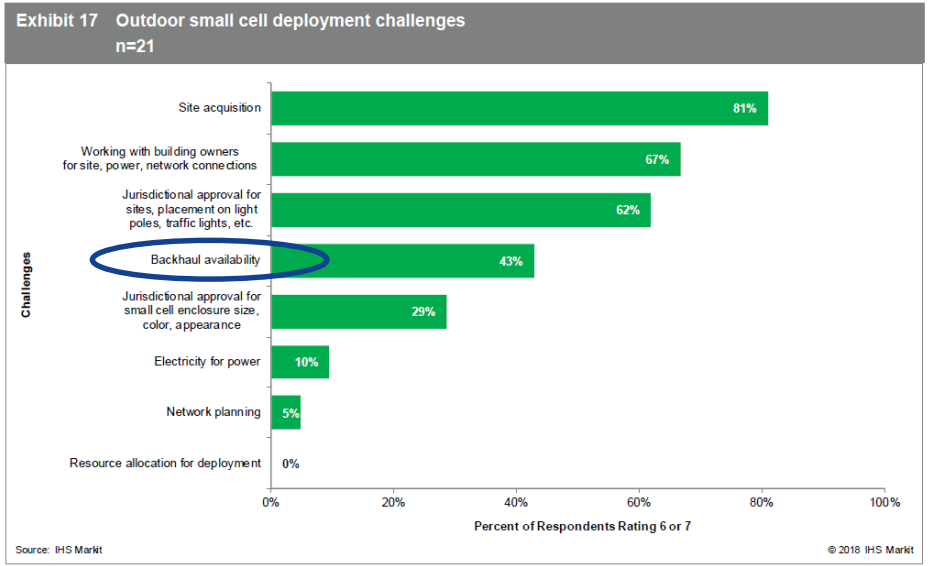
Focus here is densification provided by 5G mmWave networks

→ need for reliable backhaul solutions on top of fiber

→ PtP E-band powerful solution, but rule change necessary to fully enable it and corresponding 5G use cases

Densification challenges





From IHS market analysis (“Small Cell Strategies and Vendor Leadership - Service Provider Survey” Oct 2018) backhaul is one of the main hurdles for small cells.

5G Network trends & Microwave Industry

Networks evolution

- Fiber penetration up
- Density up
- Coverage up

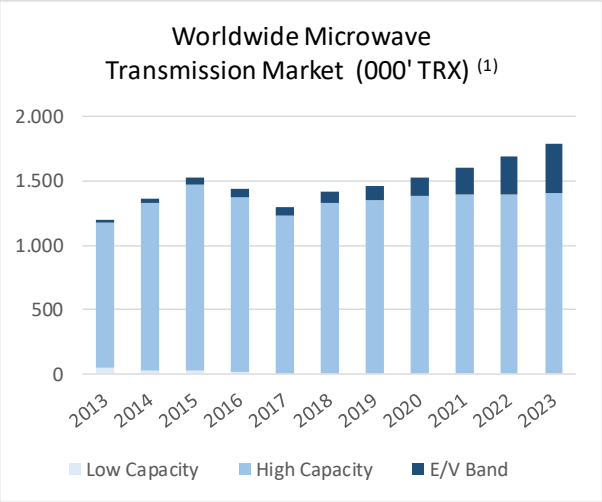
MW remains a key technology

(already used today in more than 50% sites)

Dell'Oro market analyst

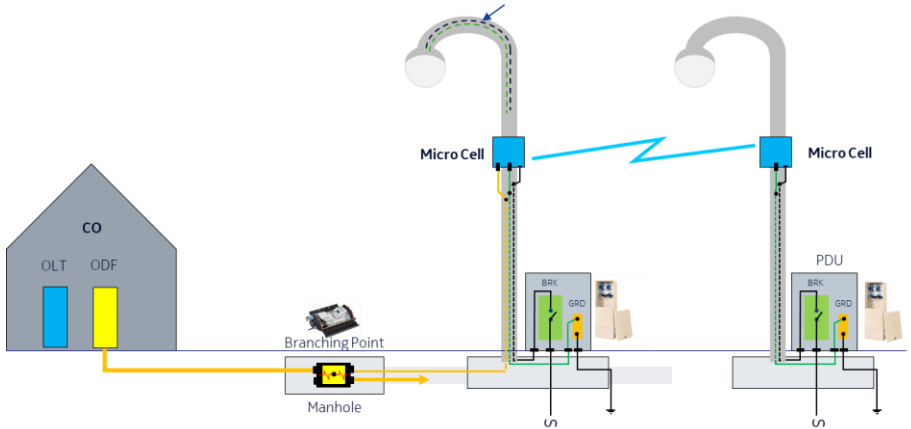
"PTP microwave will meet the capacity demands of most 5G macro cell sites for many years to come, and operators that want to stay with wireless backhaul over fiber can continue to do so with 5G."

"The transport layer will play an important part in defining the success of 5G, just as it did for 4G. This means operators will need to continue upgrading mobile backhaul capacity to meet the increasing amount of user bandwidth. The good news is that 5G will not force operators to forego wireless backhaul for fiber, operators without an intention to own fiber plants will not be disadvantaged, and PTP microwave vendors will continue to see many more years of growth."



(1) Dell'Oro Group INC – January 2019 MICROWAVE TRANSMISSION & MOBILE BACKHAUL FIVE YEAR FORECAST REPORT- 2019 - 2023

5G densification

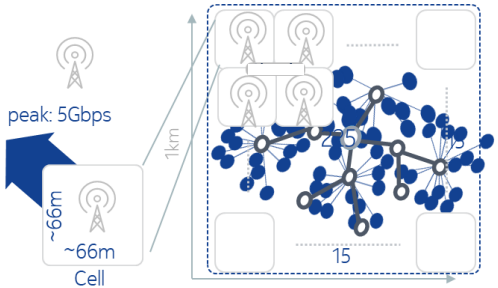


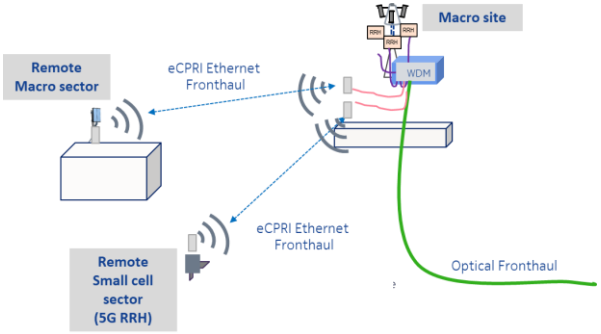
Wireless connectivity/transport as **enabler for 5G:**

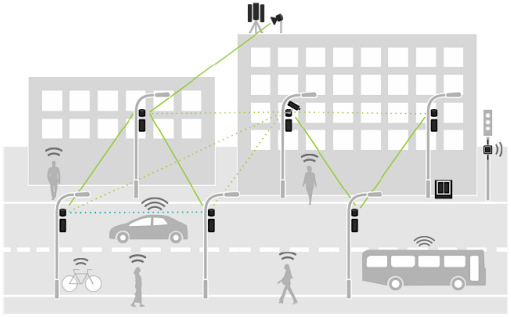
- fiber might not available in the deployment area
- fiber PoP is just one or few hundred meters away from the radio access point

Estimation for US dense urban scenario which needs 5G deployment:
50% of sites not covered by fiber
(25% temporary, 25% long term)

5G densification scenarios
Mobile x-Haul







5G Millimeter-wave Wireless deployment
- 26/28/39 GHz
- **Backhaul / F1**

Remote RRH Macro-sector /small cells
- Sub-6GHz RRH and Small cells (Micro RRH)
- **eCPRI fronthaul**

Small Cells low power (street level)
- SUB-6GHz (or mmW)
- **Backhaul / F1**

5G Network trends & Microwave Industry

Networks evolution

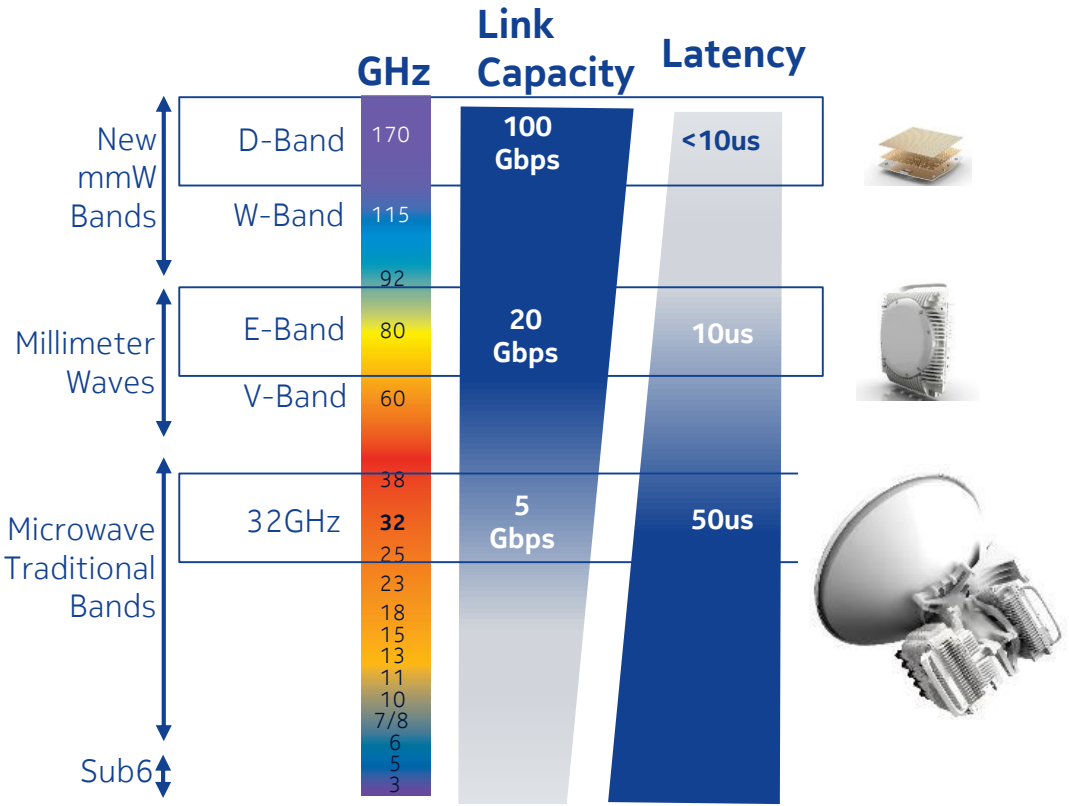
- Fiber penetration up
- Density up
- Coverage up

MW remains key technology

Microwave technology

- More spectrum defined
- Silicon techno jumps

> 10 Gps, 10 µs of latency up to 100 Gps tomorrow



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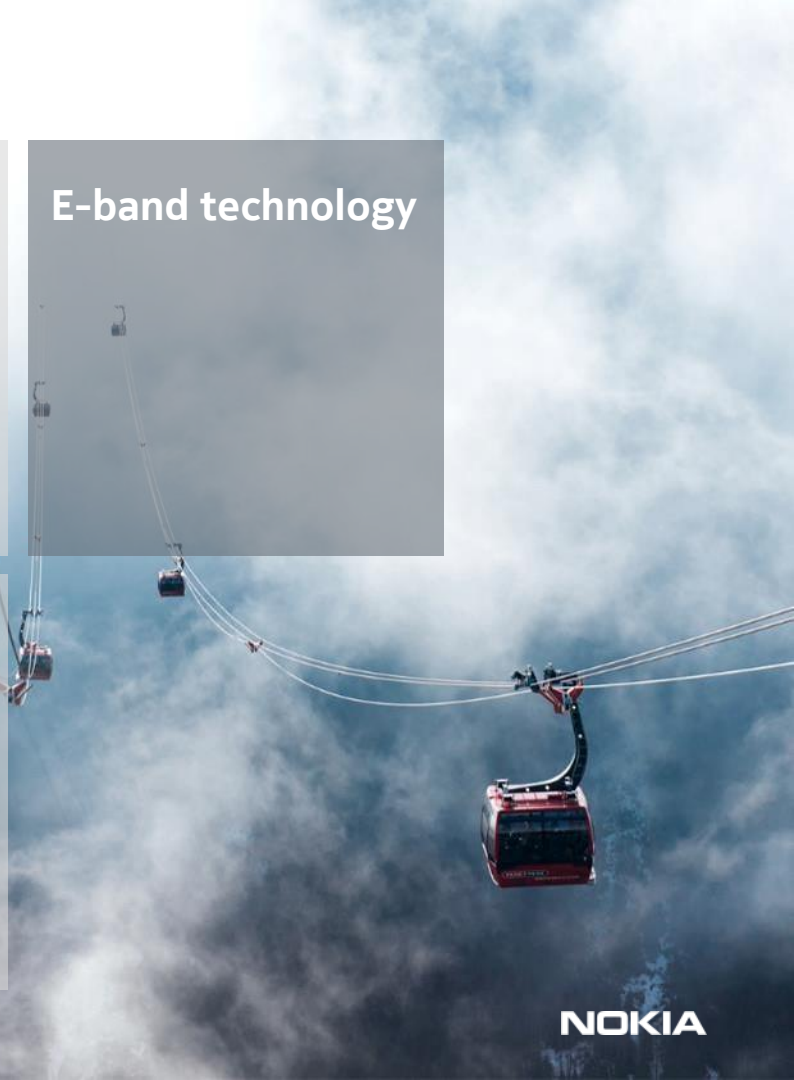

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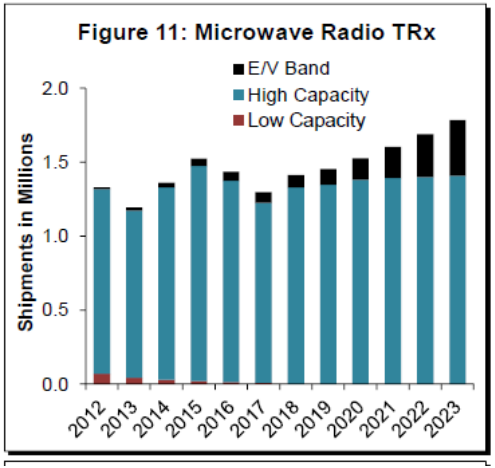
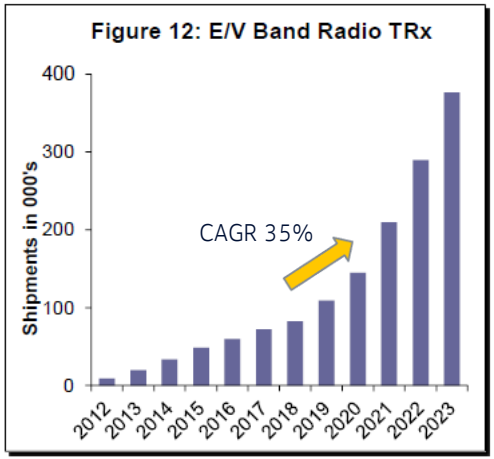
E-band for transport





(Dell'Oro - 2019)

E-band is more and more exploited for last mile transport and for aggregation. This is coherent with network trends:

- Densification → shorter mmWave wireless transport links
- Capacity increase (and latency reduction) needs
- Ethernet fronthaul

E-band market growing +30% YoY

NOKIA

E-band use cases

E-band going to become the most used frequency for wireless transport due to its versatility vs use cases:

E-band (and future evolution to D-band) are the only viable solutions to enable true 5G densification

Suburban

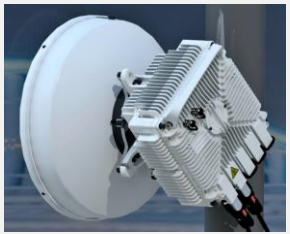
- Up to 10 Gbps for 5G backhaul/midhaul up to 5miles
- Carrier aggregation microwave + E-band

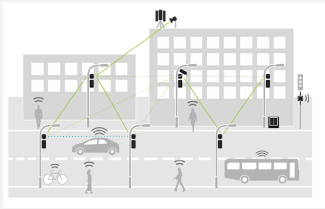
2ft dual band antenna

Urban

- 10-20 Gbps for 5G backhaul/midhaul up to 2 miles
- E-band only

1ft/2ft antenna (43-50dBi)





Dense urban

- 10/20 Gbps for 5G backhaul/midhaul/FH short distance @street level
- E-band only w/ High integration

38dBi embedded antenna

E-band flexibility addressing several use cases and 5G introduction (needed today)

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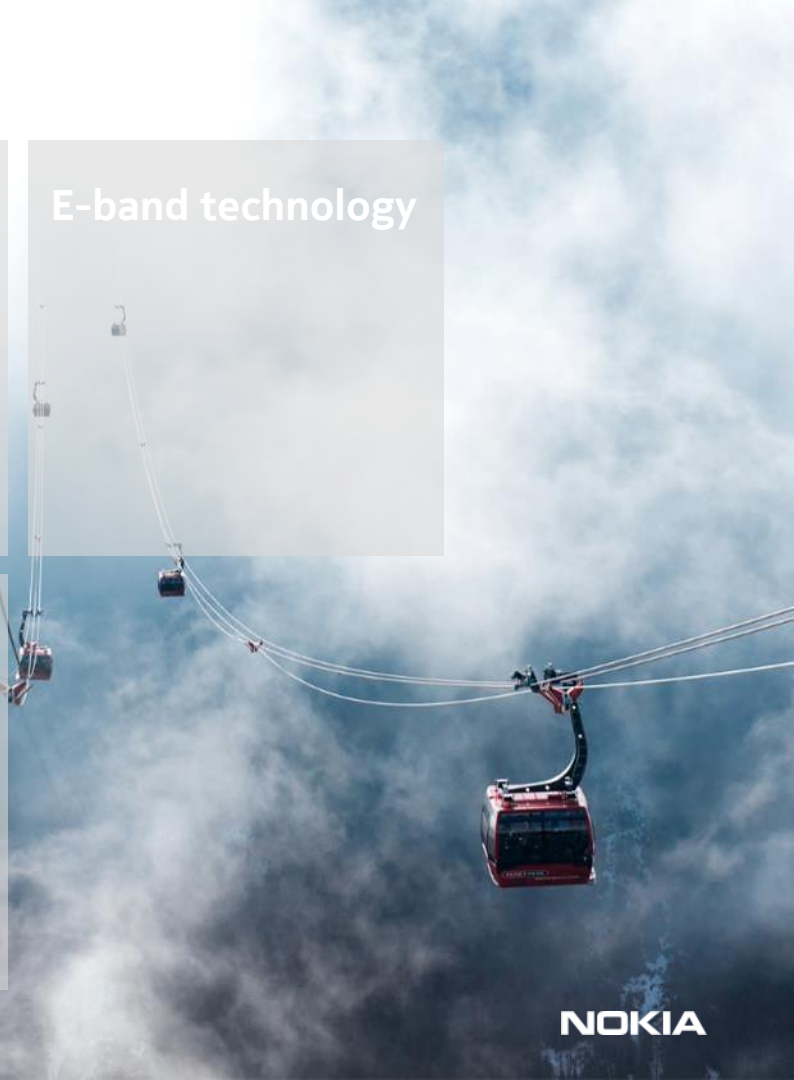

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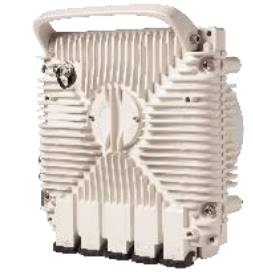
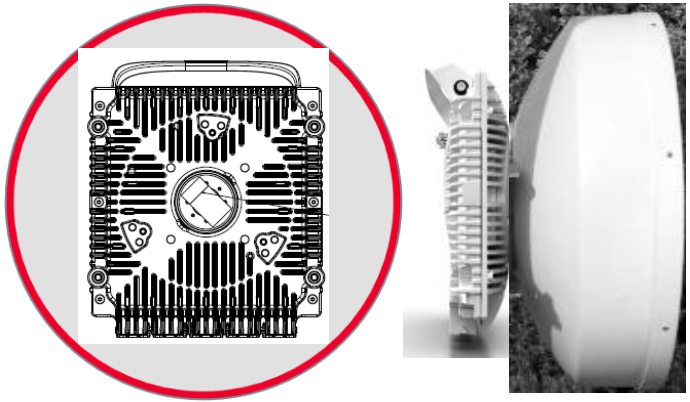
E-band products

Main UBT-m characteristics:

- Ethernet transport for macro and small cells
- Up to 2GHz channels
- 10/20 Gbps bidirectional capacity
- Small form factor
- Embedded antenna option



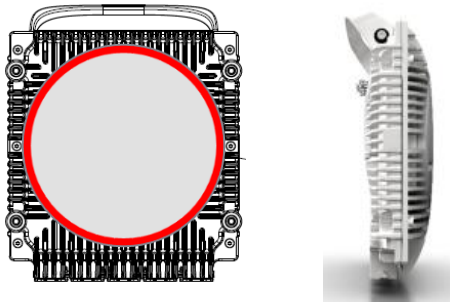
E-band antenna evolution



43dBi

- Traditional parabolic antenna
- Very thick
- 43dBi
- 1 foot

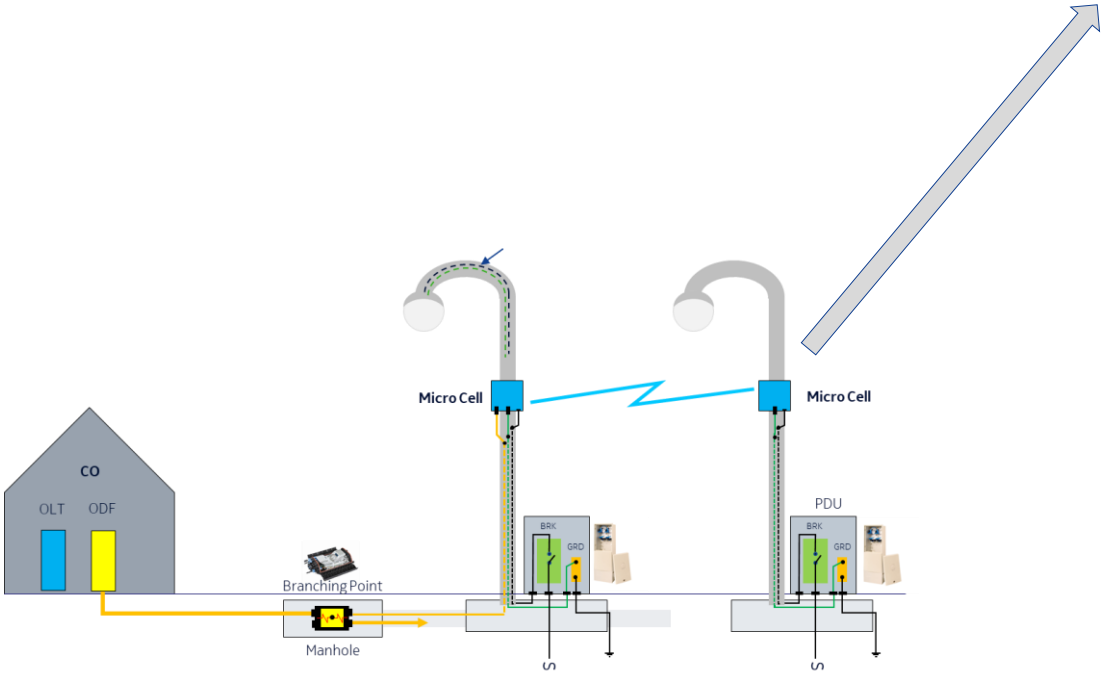
VS

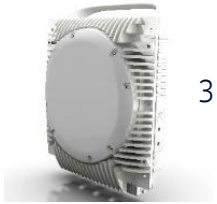


38dBi

- Innovative embedded antenna
- Minimal visual impact
- 38dBi
- 0.5 foot

E-band antenna evolution





38dBi gain

Mandatory for street level application:

1) Visual impact
2) Weight/space and easy installation on street furniture
3) Site TCO
4) Pole vibrations support
5) 43dBi would be overdimensioned and would not support pole vibrations

No drawbacks as same spectral efficiency (thanks to EIRP reduction rule vs antenna gain)

Previous FWCC proposal

We support previous FWCC proposal on this matter:

February 13, 2018: On behalf of the Fixed Wireless Communications Coalition, Inc. (FWCC),

Re: **WT Docket No. 10-153, *Amendment of Part 101 to Facilitate Wireless Backhaul***

GN Docket No. 14-177, IB Docket No. 15-256, RM-11664, WT Docket No. 10-112, IB Docket No. 97-95, *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, et al.

The FWCC asks the Commission to act:

- Smaller antennas for fixed point-to-point operations
- **38dBi as minimum antenna gain in E-band**

Worldwide regulation

Here is status in ETSI and Canada:

- The ETSI standards, which apply to dozens of countries across Europe, Africa, and Asia, are more relaxed than the Commission's; and the ETSI TM04 meeting in December 2017 proposed a further relaxation down to 30dBi.
- ISED Canada has issued its SRSP-371.0 standard with antenna requirements that are more relaxed than those in Part 101 (38dBi are allowed)

In previous proposal we asked the Commission to amend the current requirements to include both Category A and Category B antenna standards, in line with the rules for most other Part 101 bands. This would also better harmonize with Canadian requirements, which have Category A and B rules.

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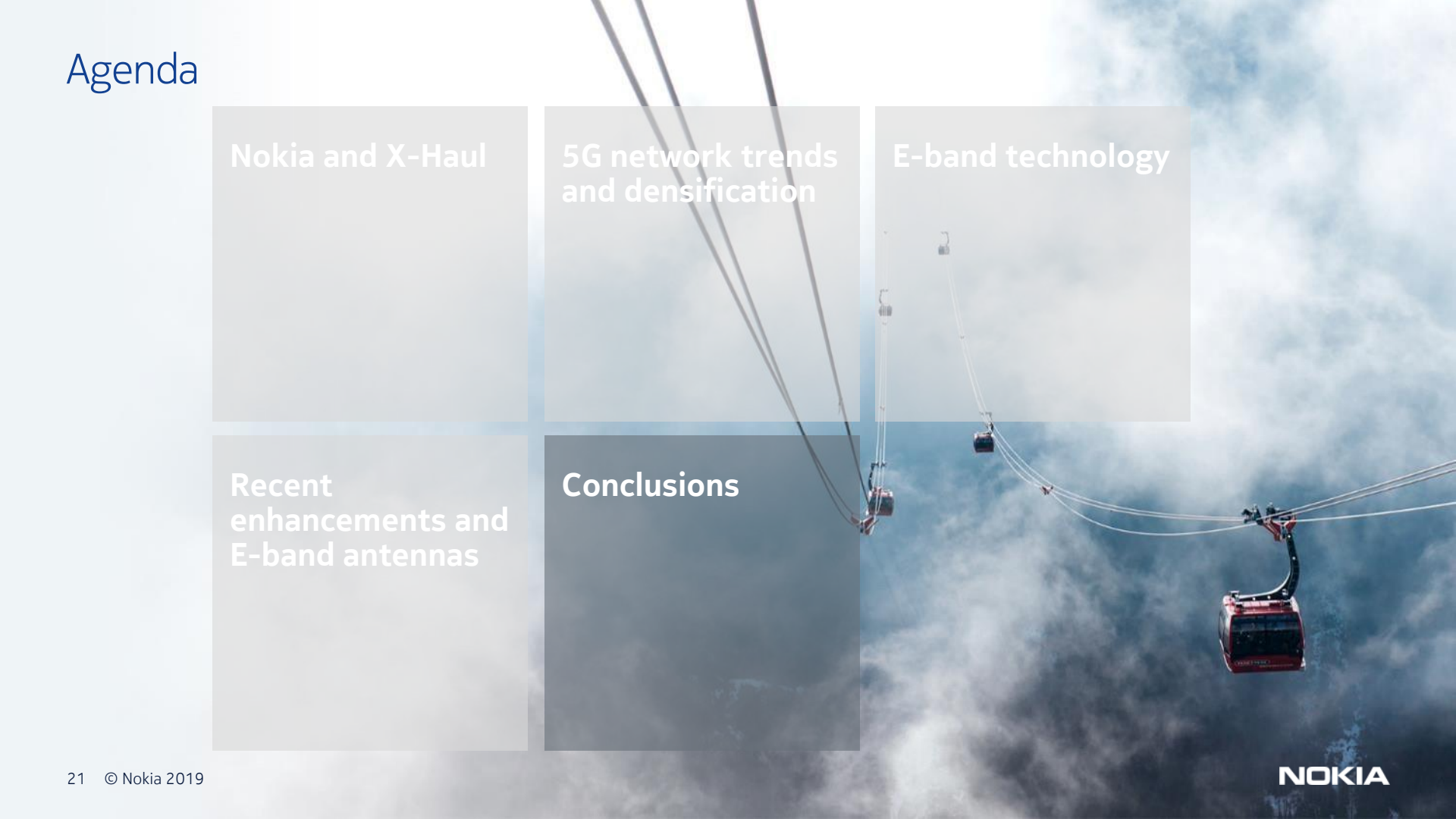


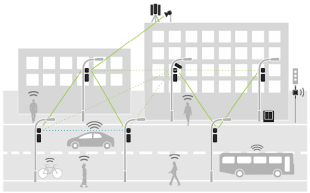
Conclusions

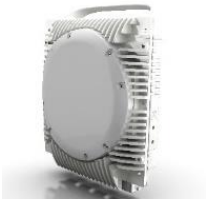
- Today operators need solutions to make existing networks evolve to support **5G introduction** and its promises
  - 5G demands a highly dense grid. This is acknowledged also by FCC ("FCC Acts to Speed 5G Rollouts"):

    "The FCC estimates that hundreds of thousands of these small cells will have to be built in the next five years to implement the infrastructure necessary to deliver super high speed, super high bandwidth service at millimeter wave frequencies that are only effective over short distances"

- Not all cell sites are served by fiber (especially at street level with 5G mmWave and small cells), but **uWave/mmWave transport technology** and especially E-band 70/80 GHz have evolved to provide the necessary KPIs

- Antenna gain rules on E-band backhaul need to be amended to enable new scenarios linked to 5G densification at street level (**38dBi** antennas needs to be allowed)
  - Supported by main US operators



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Smaller antennas for fixed point-to-point operations

Substantially:

- Minimum antenna gain should be 38dBi
- Introduction of same approach as lower bands with antenna category A and B antenna
- Maximum 3dB beamwidth = 2.2 °
- Min radiation suppression to angle as in the table
- All others rules unchanged, like the proportional reduction in maximum authorized EIRP in a ratio of 2 dB of power per 1 dB of antenna gain.
    - For the specific case the maximum allowable EIRP for 38 dBi antennas is +31 dBW

Frequency (MHz)	Category	Maximum beamwidth to 3 dB points (included angle in degrees)	Minimum antenna gain (dbi)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels						
				5° to 10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
71,000 to 76,000 (co-polar)	A	2.2	38	22	28	32	35	37	55	55
81,000 to 86,000 (co-polar)	A	2.2	38	22	28	32	35	37	55	55
71,000 to 76,000 (cross-polar	A	2.2	38	35	35	40	42	47	55	55
81,000 to 86,000 (cross-polar)	A	2.2	38	35	35	40	42	47	55	55
71,000 to 76,000 (co-polar)	B	2.2	38	13	20	28	31	32	48	48
81,000 to 86,000 (co-polar)	B	2.2	38	13	20	28	31	32	48	48
71,000 to 76,000 (cross-polar	B	2.2	38	33	33	33	38	40	48	48
81,000 to 86,000 (cross-polar)	B	2.2	38	33	33	33	38	40	48	48

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Antenna RPE proposal